Tollbooth

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Introduction

Create the working gate for making a working prototype of a a tollbooth gate state machine. In this project, students learn how to use VEX kits and how to build a working prototype. Students get more advanced knowledge from using Multisim, H- driver, drawing PLD sketches, combining VEX and state machine.

Materials

Description	Quantity	Part #
Multism	1	14.1
Wires	-	-
3 Wire Extension Cables	3	276-1424
Limit Switch	2	276-2174
2 Wire Motor 393	1	276-2177
N/A	1	84-Tooth Gear
Screws	2	8-32 x ½ Long Button Head
Gear	1	12-Tooth
Shaft	1	3" Long
Shaft	1	2" Long
Bearing Flats	4	N/A
Shaft Collars	4	N/A
Bearing Mounting Pop Rivets	8	N/A
Nuts	2	8-32 Keps
Breadboard	1	800949B-01
FPGA	1	CMOD S6
Power Supply	1	01PS28
Cables	2	Male to female
Stand offs		2 inch 8 x 32 holes
myDAQ	1	-

Design Brief

Client: Tollbooth Company

Designer: Amber Rana & Keyur Rana

Design Statement: Design, test, and build a functioning gate

Constraints:

Four inputs:

- Open Switch Pushbutton (Activates the gate) On/Off = 1/0
- Close Switch Pushbutton (Activates the gate) On/Off = 1/0
- Open Limit Switch On/Off = 1/0
- Close Limit Switch On/Off = 1/0

Four outputs:

- Motor Open On/Off = 1/0
- Motor Close On/Off = 1/0
- Gate Open – LED (Green) On/Off = 1/0
- Gate Close –LED (red) On/Off = 1/0

Deliverables

- Multisim
- Breadboard Circuit
- VEX kit

Evidence of Analysis(K-maps)

MO	OL	OL'
Qa'Qb'	0	0
Qa'Qb	1	1
QaQb	0	0
QaQb'	0	0

Qa'Qb

MC	OL	OL'
Qa'Qb'	0	0
Qa'Qb	0	0
QaQb	1	1
QaQb'	0	0

QaQb

GO	OL	OL'
Qa'Qb'	0	0
Qa'Qb	0	0
QaQb	0	0
QaQb'	1	1

QaQb'

GC	OL	OL'
Qa'Qb'	1	1
Qa'Qb	0	0
QaQb	0	0
QaQb'	0	0

Qa'Qb'

Evidence of Analysis (Truth Table)

State	Qa	Qb	OS	CS	OL	CL	State	Qa*	Qb*	MO	MC	GO	GC
S0	0	0	0	X	X	X	S0	0	0	0	0	0	1
S0	0	0	1	X	X	X	S1	0	1	0	0	0	1
S1	0	1	X	X	0	X	S1	0	1	1	0	0	0
S1	0	1	X	X	1	X	S2	1	0	1	0	0	0
S2	1	0	X	0	X	X	S2	1	0	0	0	1	0
S2	1	0	X	1	X	X	S3	1	1	0	0	1	0
S3	1	1	X	X	X	0	S3	1	1	0	1	0	0
S3	1	1	X	X	X	1	S0	0	0	0	1	0	0

OS = Open Switch Pushbutton 1 = on

MO = Motor Open 1 = on

CS = Close Switch Pushbutton 0 = off

MC = Motor Close 0 = off

OL = Open Limit 1 = on

GO = Gate Open 1 = on

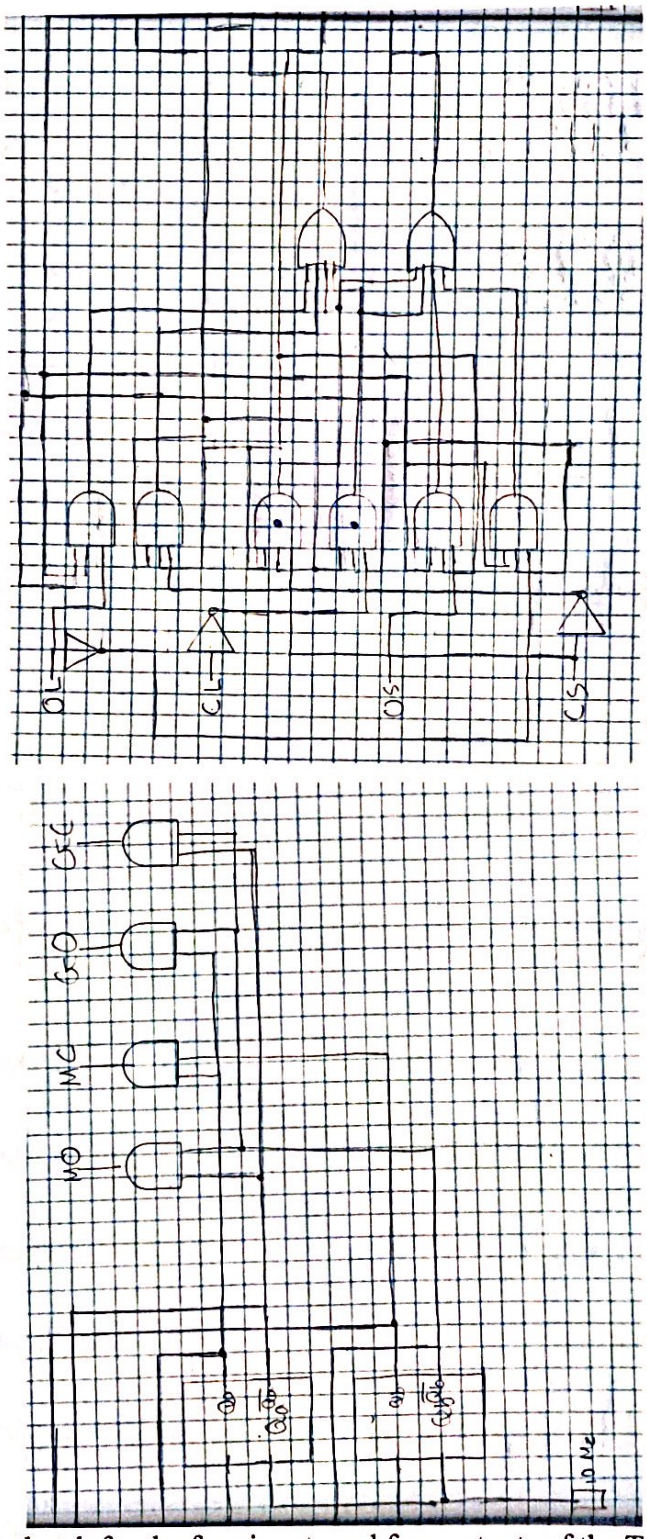
CL = Close Limit 0 = off

GC = Gate Closed 0 = off

Da= Qa*= Qa'QbOL + QaQb'CS' + QaQb'CS + QaQbCL'

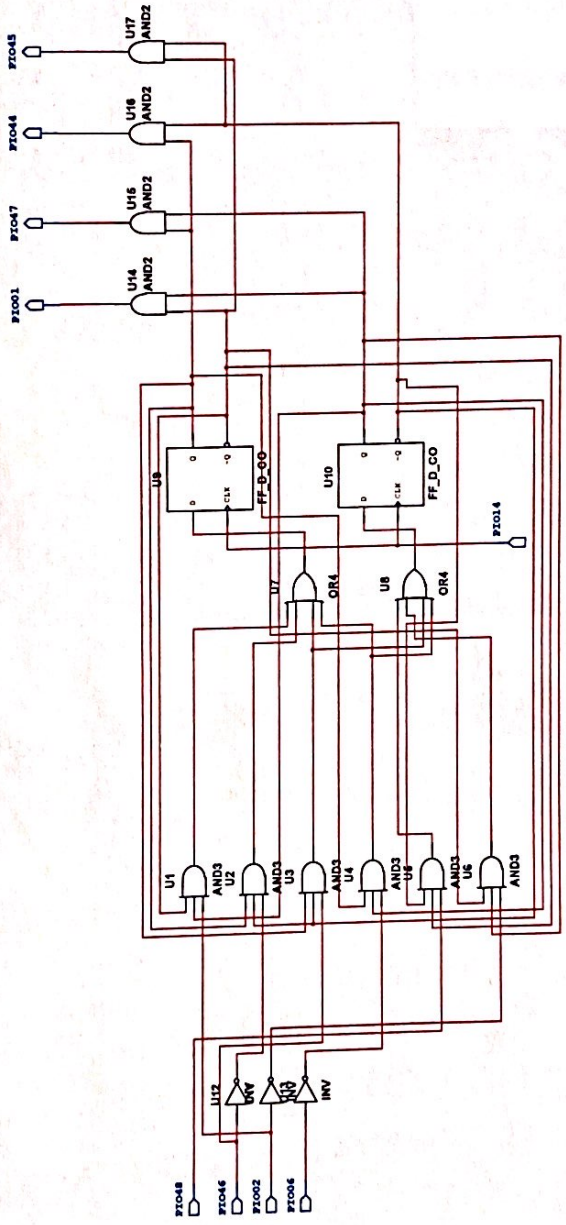
Db = Qb* = Qa'Qb' + Qa'QbOL' + QaQb'CS + QaQbCL'

Evidence of Working Analysis (Sketch)



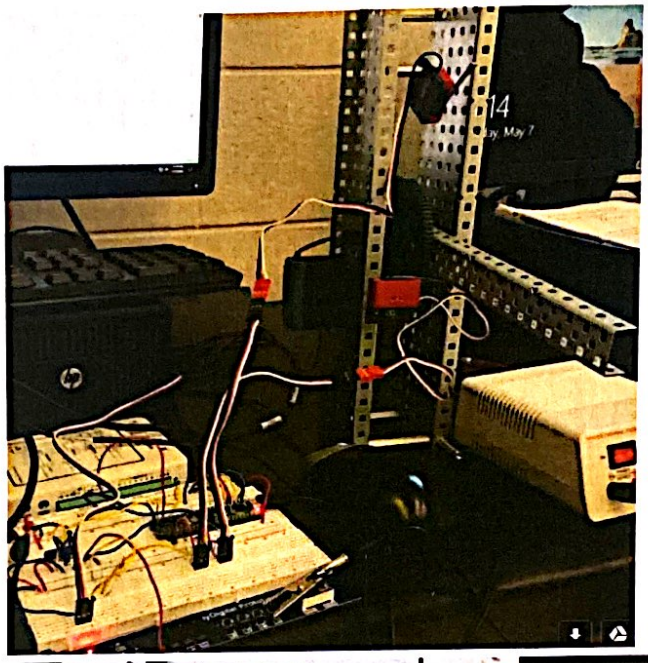
Circuit sketch for the four inputs and four outputs of the Tollbooth

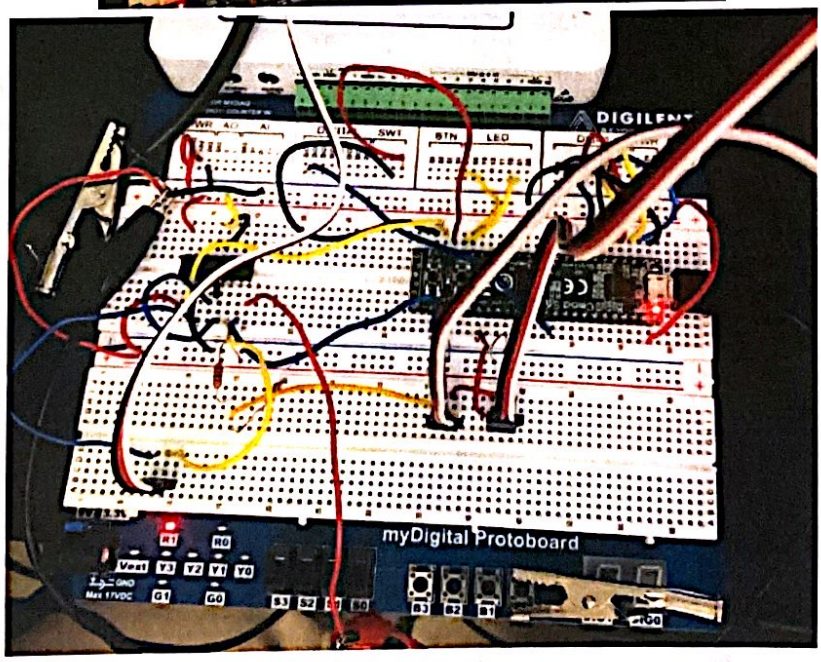
Evidence of Working Design (Program)



The working circuit built on Multisim in PLD mode

Evidence of Working Design (Working Prototype)





Working prototype of Tollbooth. Red light turns on as the gate reached the close limit.

Conclusion

The purpose of this project was to create a gate for the tollbooth. Skills learned are VEX kit, truth tables, k-maps and AOI logic gates. The students were to design, test and build a function gate for tollbooth. The students started off by making a design brief, identifying the inputs (OS, CS, OL, CL), and outputs (MO, MC, GO, GC), making the truth table, and k-maps for every output and then sketching the circuit on their Engineering Notebook. Finally constructing the circuit on PLD and on breadboard attached with the actual build. In this project, students used the main components like CMOD S6 to make the circuit work. Students also used a H-bridge and an external power supply that outputted a 6 volts to allow the H-bridge to output 6 volts for the motor to work. In this project, I was in-charge of mostly software and a little bit of hardware. I built the circuit on Multisim in PLD mode. My partner was in charge of constructing the model. We used a lot of common sense to put the motors, switches, bar and gears correctly to ensure it worked properly when testing it. This was very important because, if gears and the bars were too long, it would create an unstable machine. This would make the model to fall over. Equilibrium was needed when building this project. Before getting the project to work, we encountered many obstacles such as, the motors getting stuck, motor not working or motor not stopping at the right time. At first, we thought it would be hardware but in reality, it was the software. We never stopped to think that it would be software because the circuit seemed to work on Multisim. We did not check after we had created the circuit, and this was a big fault on our end. We did encounter many hardware issues but they were not as big. They were easily fixed and avoidable. Some of the students encountered that their motor was spinning way to fast. The students were confused but then the teacher found out that the students had made a hardware problem and that they had attached the external power supply to the entire power train on the

board. This made the motors to take 11 volts rather than taking 6 volts. This was a mistake made by us because we had put a huge risk on the motors and the entire circuit in general because this would have possibly destroyed the components. For example, the CMOD S6, the H-Bridge and the motors. The gate is depended on the inputs of the switches. Overall, this project was very fun and the students have learned a lot over the few days working with the VEX kits. I personally found this project very interesting and I love doing hands-on projects that makes the students to think in order to solve a real life problem. I would be more than happy to know that we are doing these similar projects in near future.